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Radiative Environment and the Surface Temperature on a Microscale in a Sagebrush Biome

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RESEARCH MEMORANDUM

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THE RADIATIVE ENVIRONMENT AND THE SURFACE TEMPERATURE ON A MICROSCALE IN A SAGEBRUSH BIOME

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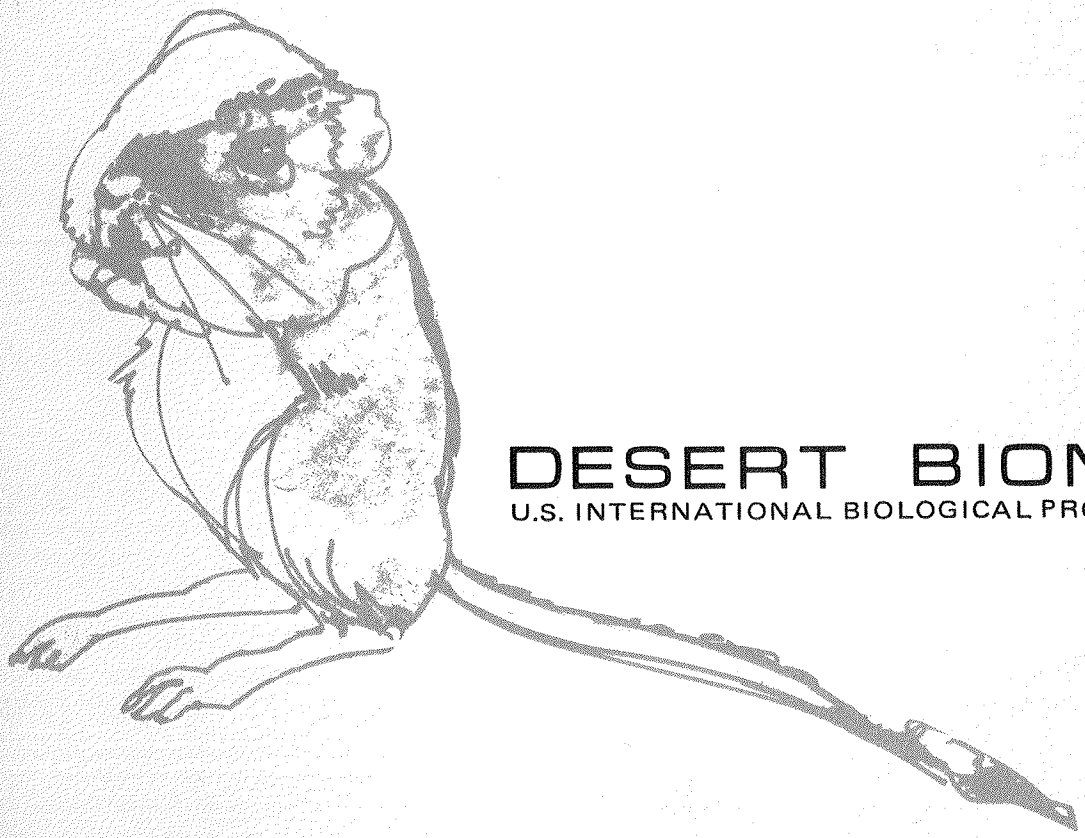


DESERT BIOME
U.S. INTERNATIONAL BIOLOGICAL PROGRAM

ABSTRACT

The radiative climate above, around and within sagebrush vegetation and the surface temperature were measured during clear days in summer of 1971. Horizontal profiles over a typical stretch of surface area, vertical profiles and the albedo of special surface features, as well as the integrated albedo over a defined grid, were investigated. Surface temperatures with extremes over 60°C were measured. An attempt was made to determine reflectance and surface temperatures with remote sensing techniques.

INTRODUCTION & OBJECTIVES

After determining the microscale radiative conditions in the Sonoran desert in 1970, the studies in 1971 were concentrated on establishing a microscale radiation climate in the sagebrush community of Curlew Valley. In addition, measurements of the surface temperature were taken to find a correlation between this parameter and radiation.

During some clear days a daily variation of the incoming, reflected (albedo) and net radiation was measured. The change of this radiation by sagebrush vegetation in and around the bushes was determined and an attempt made to describe the radiative climate encountered by a small animal or by small vegetation.

The radiation climate on a microscale was determined by the following steps:

1. Albedo over sagebrush vegetation. The method used for determining this parameter was described earlier (Dirmhirn and Belt, 1971) and was followed also in this study.

2. Horizontal profiles of incoming (solar and scattered) and net radiation profiles through and beside the bushes were taken to determine maximum and minimum values of shortwave incoming and net radiation and establish an average above the ground surface. Those profiles were correlated with surface temperature measurements.

3. Vertical profiles were obtained of solar and scattered (shortwave incoming) radiation and net radiation.

METHODS & DISCUSSION

Albedo of Sagebrush Vegetation (Curlew Valley)

Figure 1a gives a general view of the field site in Curlew Valley. The border between original sagebrush vegetation and cultivated crested wheatgrass is clearly visible. Figure 1b and 1c show a close view of the sagebrush and of the wheatgrass site, respectively. To measure albedo over a defined area a grid was laid out and albedo measured with a pyranometer on a stand 1.5 m high. The incoming solar and scattered radiation were recorded continuously. Figure 2 shows a sketch of the grid, while the illustrations in Figure 3 indicates what the pyranometer "sees." These pictures were taken with a fisheye lens.

The measured albedo values are shown in Table 1. Emphasis was given to record any variation due to non-isotropic reflection of any part of the surface or vegetative cover. The slight daily variation of the albedo of the reference area seems not to be significant. In fact, some of the daily variations over distinct surface features seem to have a slightly inverted course (low in the morning, high at mid-day) as shown in Figure 4. These values were measured with a specially constructed small pyranometer.

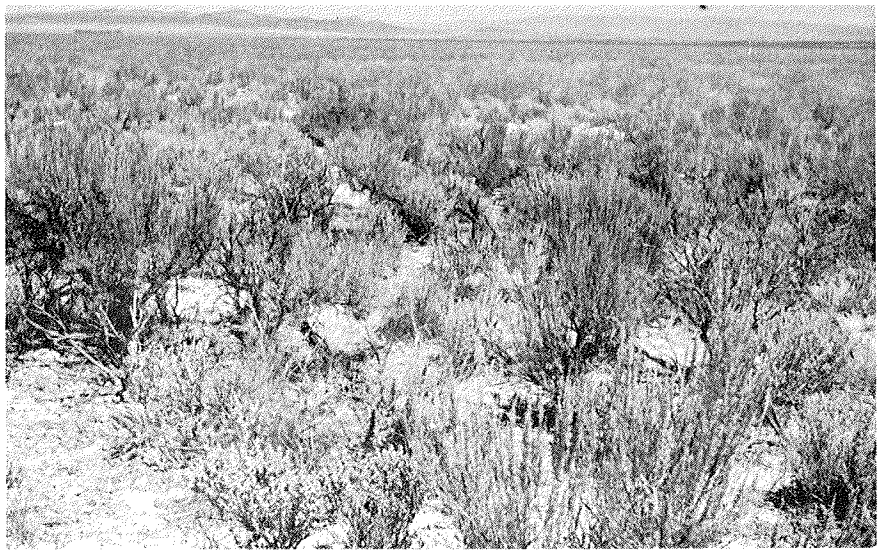


Figure 1a. General view of field site, Curlew Valley.

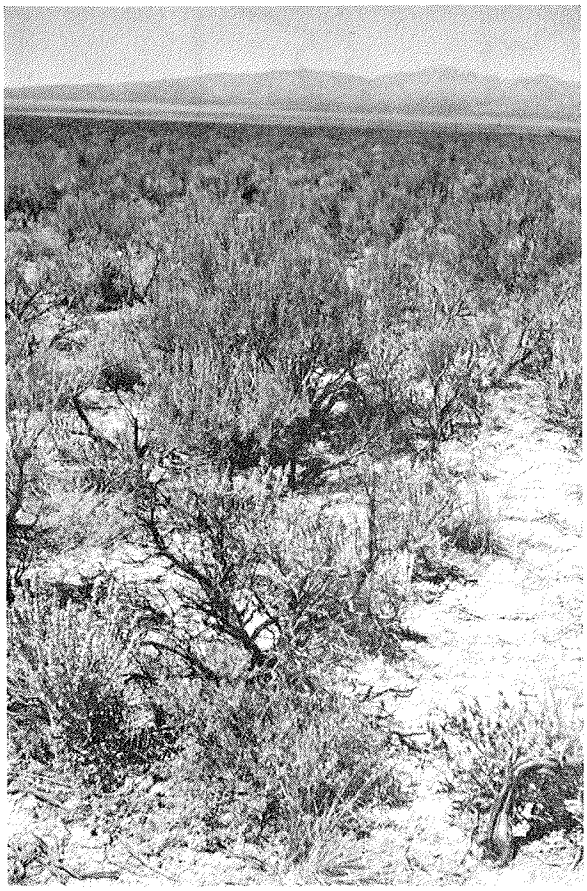


Figure 1b. Sagebrush site.

Figure 1c. Wheatgrass site.

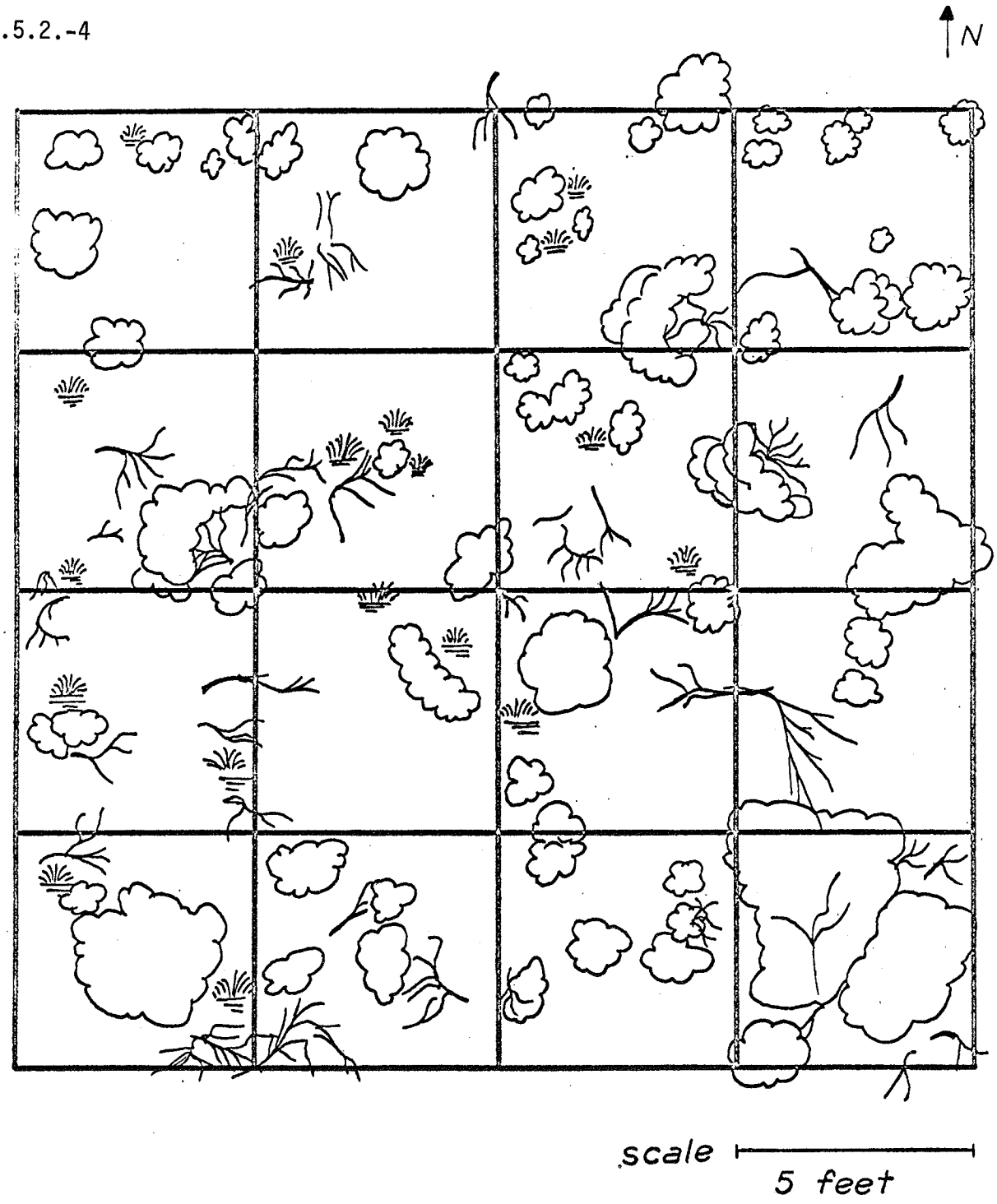
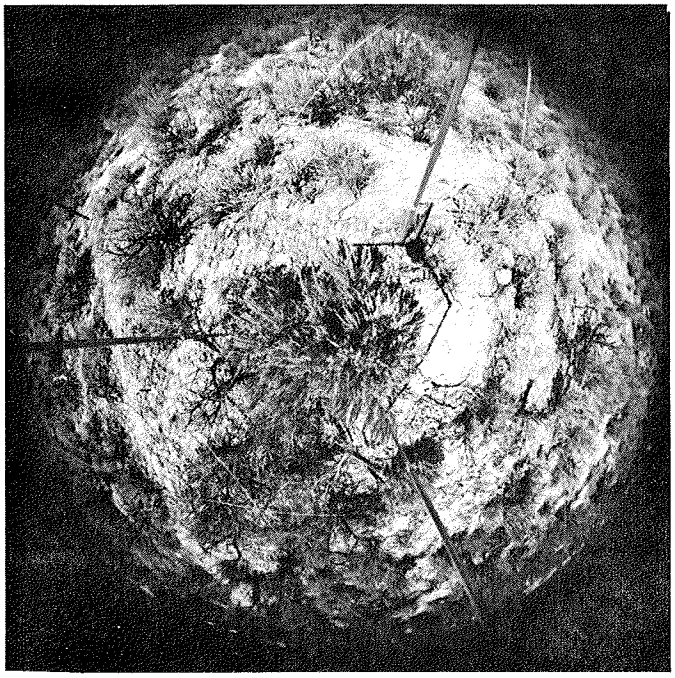


Figure 2. Grid of sagebrush albedo site.



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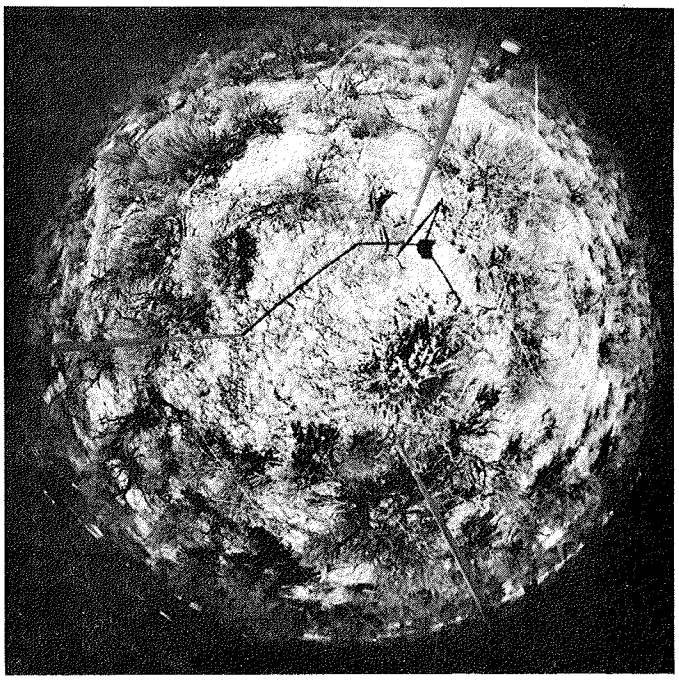

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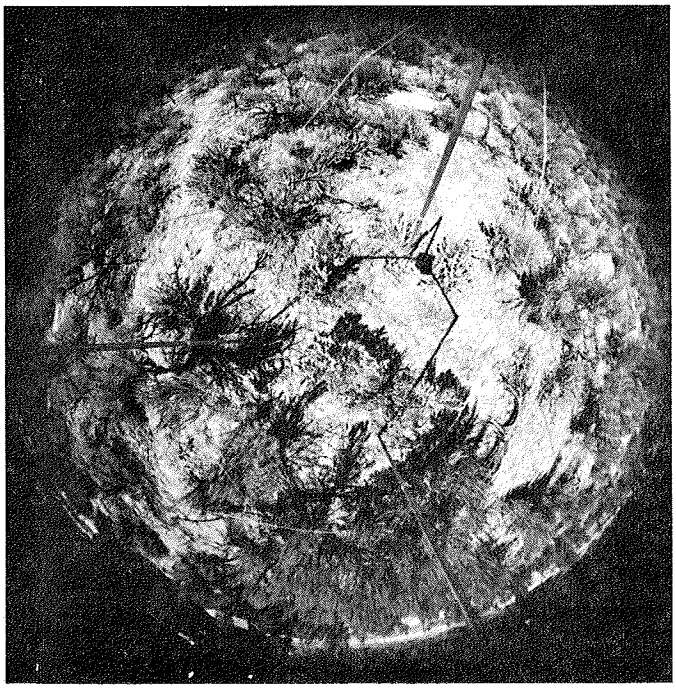

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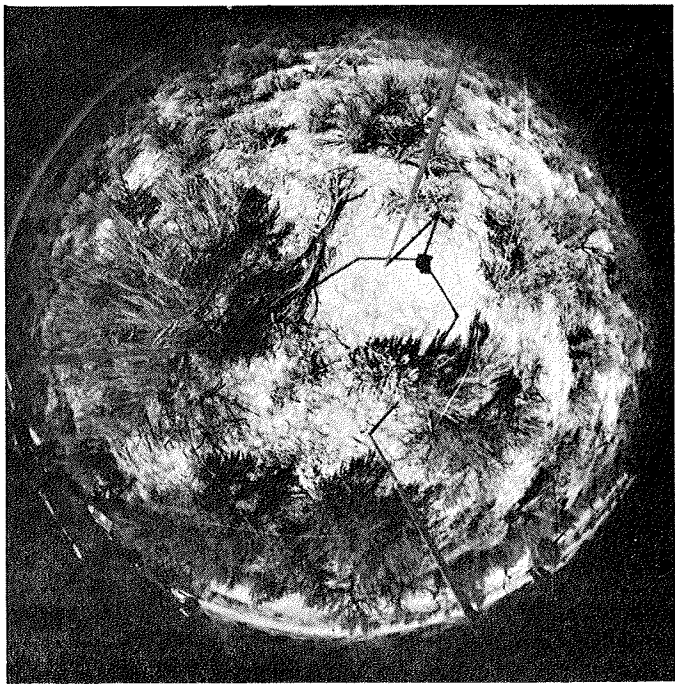

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Figure 3. Pictures taken with a fisheye lens camera looking down on some of the areas on the grid for albedo measurements (Figure 2). The fisheye lens "sees" the same as the pyranometer. The numbers correspond with the numbers in the grid.

Table 1. Albedo values (in percent) over the 16 grid points during one half day course. An obvious daily variation cannot be detected.

Time (am)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Aver.
7:08	20.6	18.3	17.6	19.2	18.5	18.7	16.7	18.7	16.7	17.6	16.5	18.1	17.9	17.3	17.6	19.2	17.8
8:00	17.2	16.7	17.4	17.3	17.5	17.7	16.5	18.3	16.7	15.4	16.4	17.8	15.8	17.1	15.5	18.1	17.0
8;50	16.7	16.4	17.9	17.4	16.6	17.1	15.4	15.6	15.2	15.7	16.3	17.1	15.9	14.9	15.2	16.5	16.2
9:50	18.0	17.7	18.0	17.6	17.1	17.0	16.3	16.7	16.4	16.2	17.4	17.9	16.8	16.8	16.3	16.7	17.0
10:45	18.8	18.5	18.5	18.5	17.3	17.0	17.0	17.0	17.3	17.0	17.7	17.8	17.0	17.0	16.8	16.2	17.4
12:00	17.5	16.9	17.7	17.2	16.4	16.4	16.2	16.4	16.4	16.0	16.4	16.7	16.2	16.0	16.4	15.2	16.5

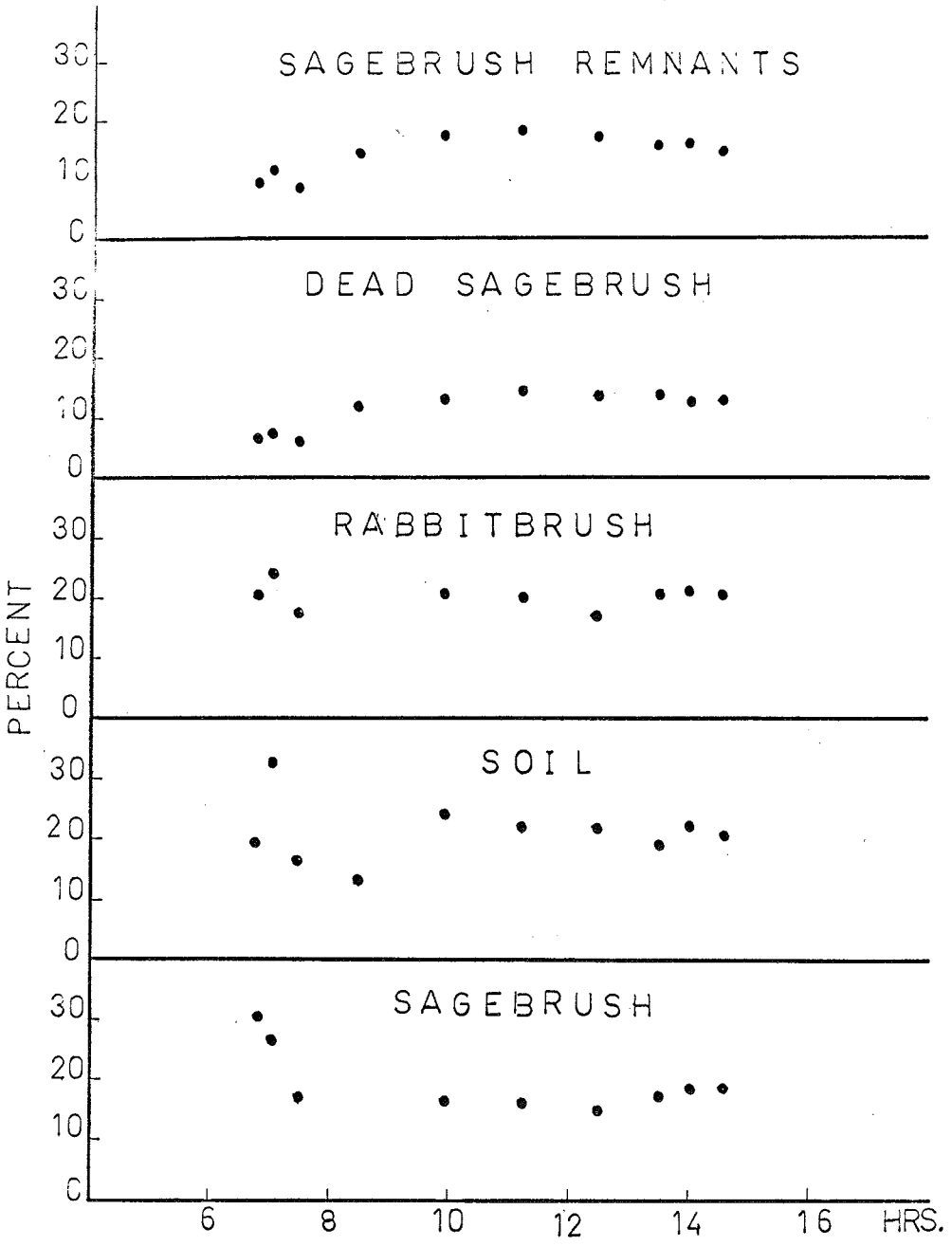

Figure 4. Daily variation of albedo at Curlew Valley, 11 Aug. 1971.

Horizontal Profiles of Direct and Scattered Solar Radiation and Net Radiation; Surface Temperature

Two different approaches were used to find extreme and average values of the radiation components and correlate these with measured surface temperature. These were:

1. Profiles along an approximately 30-foot stretch at random through the sagebrush area.

2. Radiative and surface temperature conditions around and through one typical sagebrush.

To determine the possible variations, a stretch of sagebrush vegetation was chosen, which seemed to show the different features found in this community. These were live sagebrush, dead sagebrush, broken down remnants, bare soil, shadscale and grass.

The profiles were measured above the vegetation and at 20 cm above the ground through the bushes.

Figure 5 gives an example of the radiation components and the surface temperature along this profile. Incoming solar and scattered radiation and albedo were measured with the mini-pyranometer; a net radiometer (Kahlsico) was used for the net cross sections. The surface temperature was measured with a Barnes IT-4 Thermal Master.

Though this was not an extreme case, temperatures of more than 50°C were frequently measured, as shown in Figure 5, on bare places. Sunlit areas with protecting (and reflecting) bushes nearby offered extremely high temperatures. There, on other occasions, temperatures of over 60°C could be found. Data of these extreme values, as well as a comparison of the radiative energy with the surface temperature, are currently being analyzed and will be presented at a later date.

For the second approach, a sagebrush of characteristic height and density was selected and the radiative components, incoming solar and scattered, reflected, and net radiation were measured. The measurements were done at three levels from above ground to about 20 cm above the bush. Isolines of equal radiation (or surface temperature) were then drawn as shown in Figure 6. These lines vary considerably with the time of day since the shadow pattern, produced by the bush itself and by vegetation around it, has a considerable influence on the radiation pattern. During the summer pictures will be taken of the shade distribution. These, combined with measurements of the radiation components and surface temperature will give a more extensive picture of the impact of the shade area. During noon conditions, when shade is important to organisms in the desert, the affected areas are small but still effective in their impact on surface temperature (see Figure 5).

The cross sections of radiative components measured at different levels on the bush can be used for a three-dimensional graph. In this way any place above or below a previously determined radiation level can immediately be pointed out.

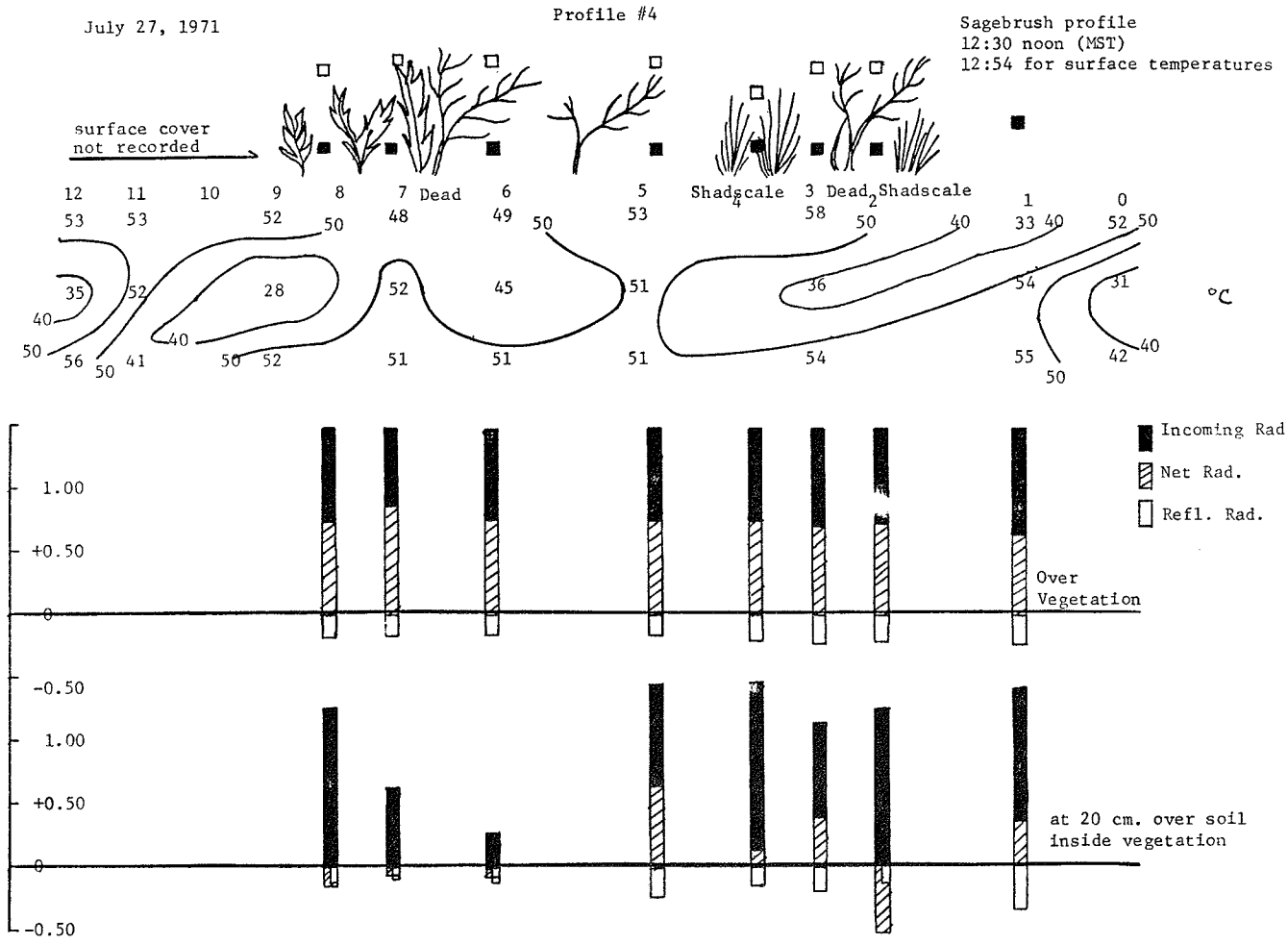

Figure 5. Incoming, reflected and net radiation as well as surface temperature through a horizontal profile of typical surface cover in Curlew Valley sagebrush site.

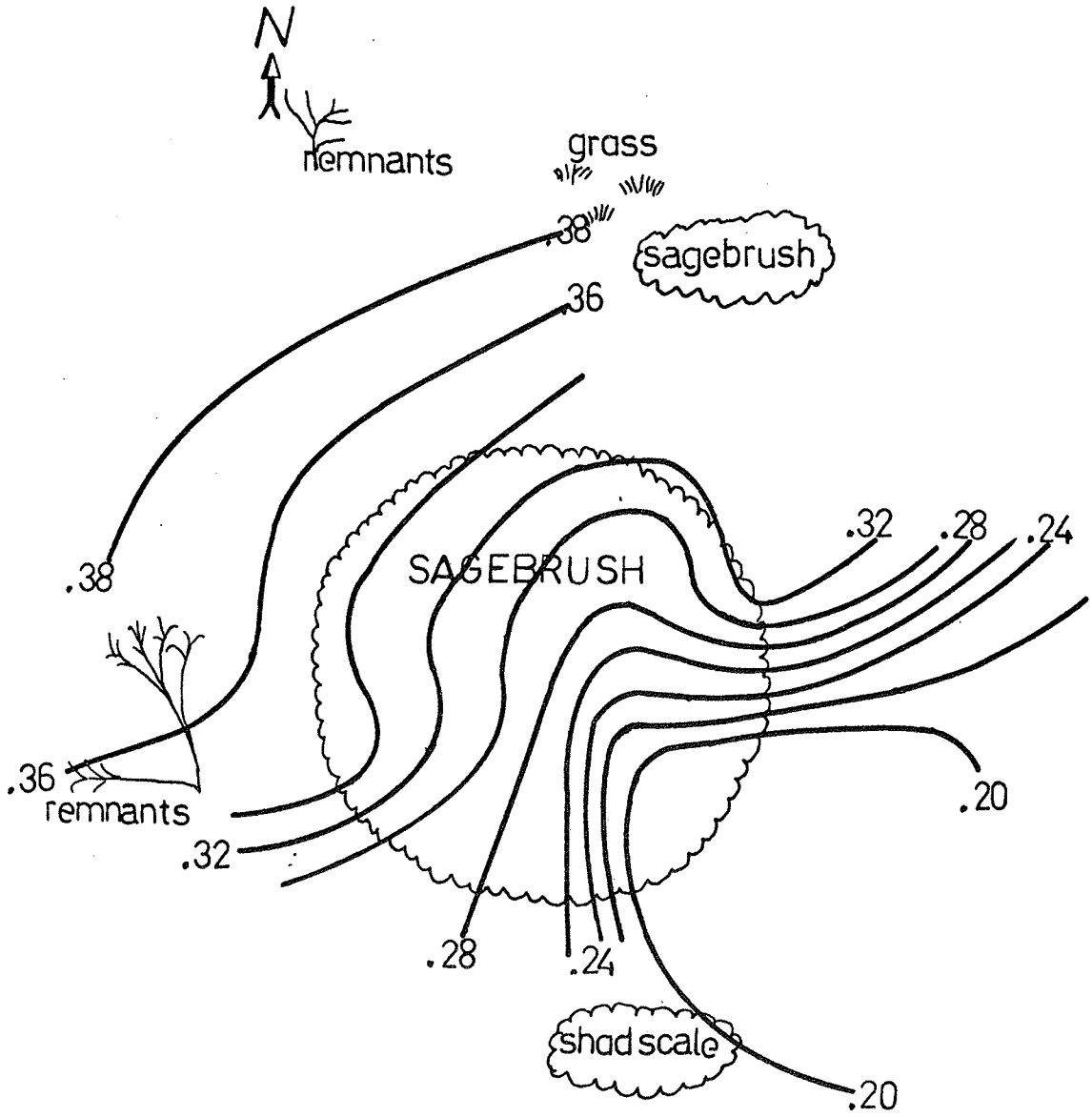

Figure 6. Isolines of net radiation around and through one typical sagebrush. This is an example for the isolines which were drawn around and through this bush at different heights above ground and at different daytimes.

Vertical Profiles of Solar and Scattered Radiation and Net Radiation

In part, the vertical profiles through a sagebrush were implicit in the findings of the previous section. There, only three levels were indicated, for the emphasis was on the horizontal distribution. In this section the vertical profile was measured on a multitude of points from the top to the bottom of well-developed sagebrush to determine averages and extremes of the radiative impact.

The following Figures show the vertical gradient of the radiative components through a sagebrush. Average curve and maximum and minimum values are drawn. In Figure 7 the decrease of incoming solar and scattered radiation is shown. This component can only become smaller with decreasing depth, except for very local and small increases caused by additional reflected radiation from leaves above the local point. In general, however, solar and scattered radiation decreases with depth.

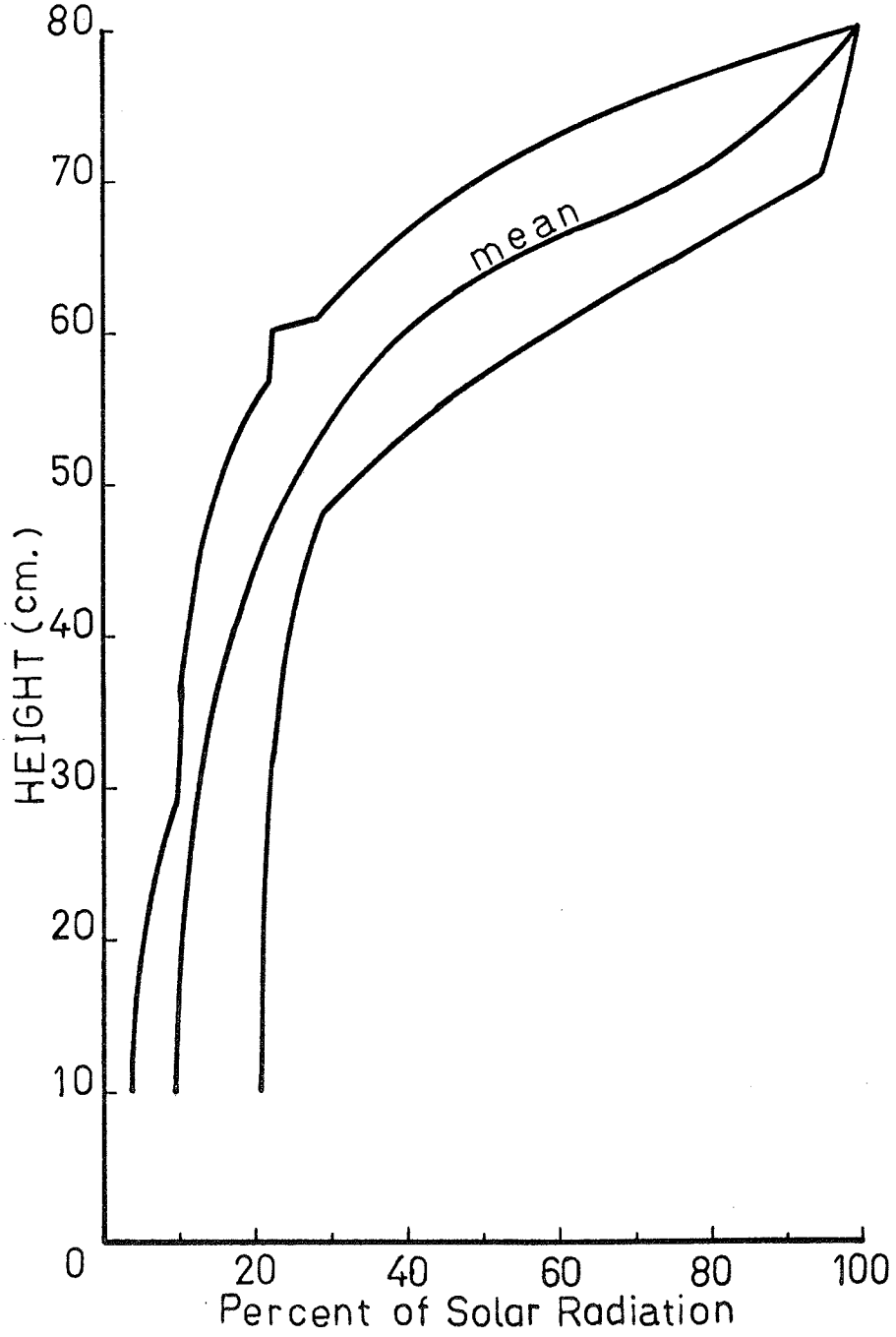

Figure 7. Vertical profiles -- average, maximum and minimum -- of incoming, solar and scattered radiation through a typical sagebrush.

This is not the case with the albedo (Figure 8). On the contrary: albedo increases with depth. This is partly due to the ratio of the area the pyranometer can "see" from above to the incoming component. (Often more shade in the downward component if measured within the bush). The reason for this increase was, in part, a spectral change in the radiation due to filtering affect of the leaves. Wavelengths of a highly reflective character are more available after radiation passes the vegetative filter. Being reflected by this same material results in an increase of the energetic value of reflectivity (albedo).

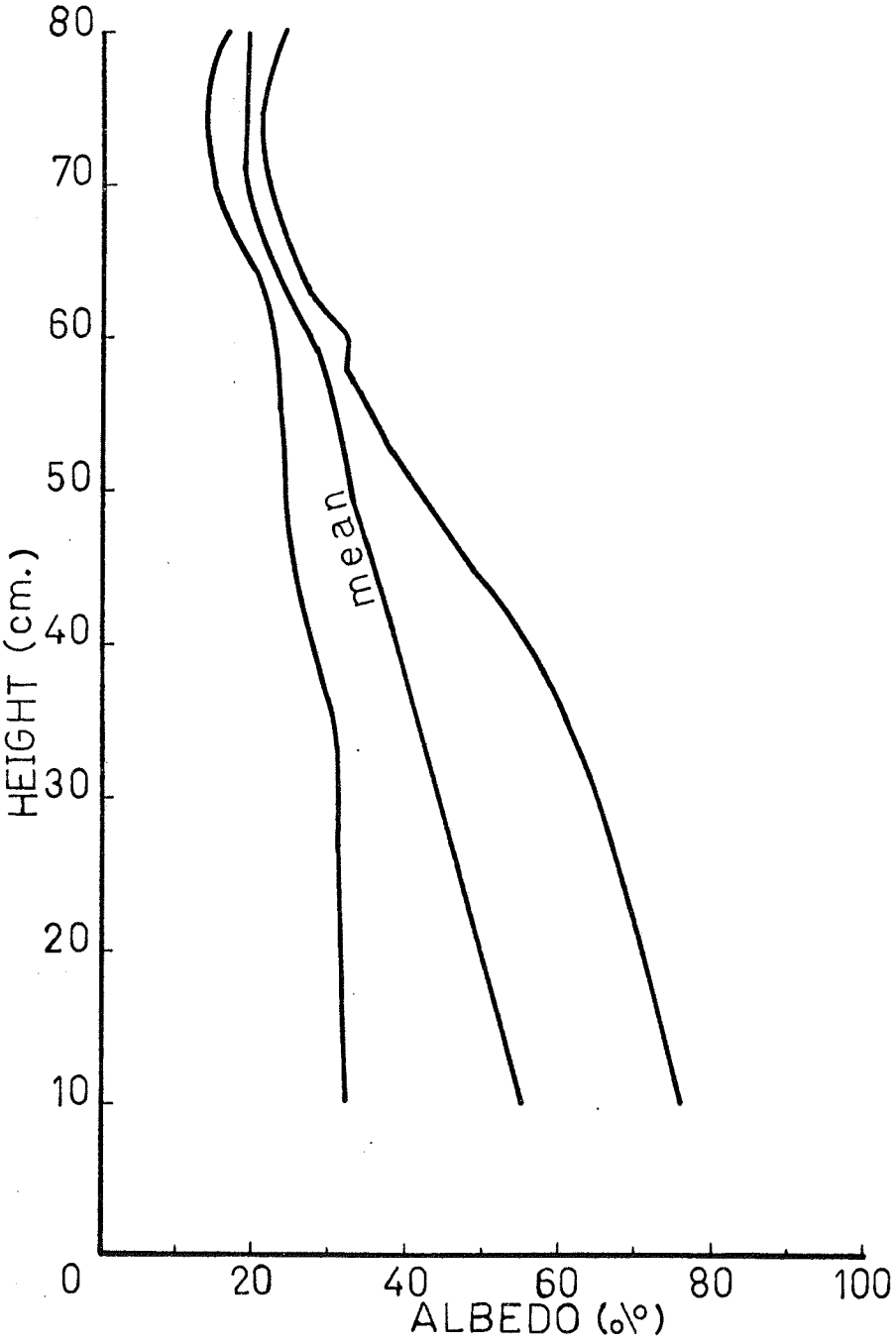

Figure 8. Vertical profiles, average, maximum and minimum, of albedo (in percent), through sagebrush.

The vertical profile of the net radiation shows an astonishing variation in higher levels of the bush. The average is still a smooth curve with a general decrease from the top down. But the individual values vary considerably, particularly in the upper part of the bush (Figure 9). Values of more than 30% of the initial amount above the bush were found. At the same level, minima of less than 10% of the value above the bush can also be observed. The variations are due to the impact of sun and shade spots. In the shade, the sunlit branches and leaves below contribute considerably to the upward-directed longwave radiation, thus reducing the net radiation to almost zero. In some sunlit areas, additional longwave radiation of the branches above the point increases the downward radiation while shade areas below reduce the upward, thus resulting in a high net radiation.

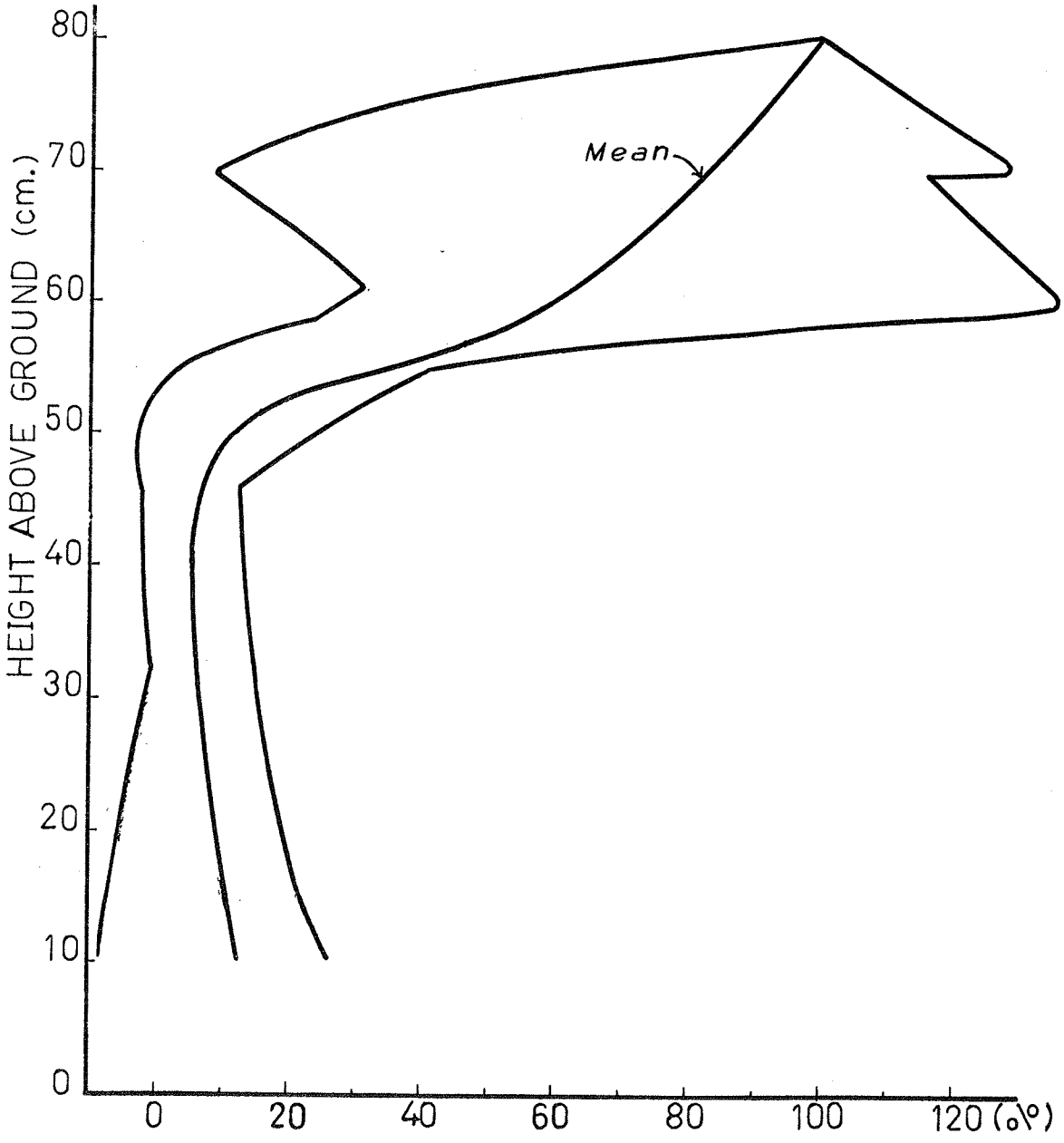

Figure 9. Vertical profiles, average, maximum and minimum, of net radiation through sagebrush.

LITERATURE CITED

Dirmhirn, I., and Belt, G.H. 1971. Variation of albedo of selected sagebrush range in the intermountain region. Agric. Meteorol. 9:51-61.